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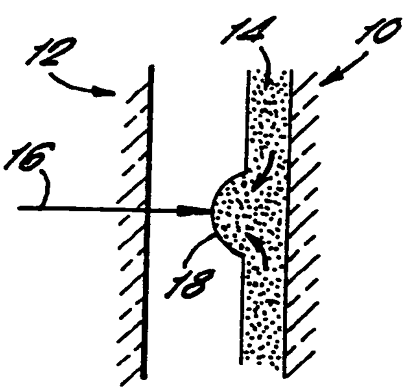

(57) Abstract

There is described a method of securing one body (12) with respect to another (10) comprising the steps of providing a fusible material (14) at an interface of the two bodies (12, 10), directing a high energy density beam (16) through a first of the bodies (12) substantially without causing any detectable change to the bulk thereof, and irradiating the fusible material (14) with the high energy density beam (16) so as to cause the fusible material (14) to fuse and secure the two bodies (12, 10) with respect to each other. In particular there is described a method of affixing a glass fitment or closure with respect to a glass bottle. There is also described an apparatus for securing one body with respect to another comprising means for creating a high energy density beam to which at least one of the bodies is transparent and which is absorbed by fusible material provided at an interface therebetween, means for directing the high energy density beams through said at least one of the bodies so as to irradiate the fusible material and cause the fusible material to fuse and interconnect the two bodies, and means to control the rate at which the two bodies and the fused material are allowed to cool. There is also described an assembly comprising two bodies having a fusible material at an interface therebetween of which only a portion has been fused, the fused portion extending between the two bodies and securing each with respect to the other. In particular there is described a glass bottle having a fitment or closure also of glass, the glass fitment or closure being fixed in position with respect to the bottle by means of fused glass.

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METHOD AND APPARATUS FOR SECURING ONE BODY WITH RESPECT TO ANOTHER

The present invention relates to a method of securing one body with respect to another and in particular, but not exclusively, to a method of affixing a glass fitment or closure with respect to a glass bottle. The present invention also relates to an apparatus for performing the method, to an assembly comprising two bodies that are secured with respect to each other and to a glass bottle having a fitment or closure also of glass, the glass fitment or closure being fixed in position with respect of the bottle.

In the drinks industry it is desirable to secure a non-return valve within the neck of the bottle in order to prevent the bottle from being refilled once empty and the contents being passed off as that marked on the bottle. However, since most of the bottles used in the drinks industry are of glass a number of problems have arisen in adequately securing the non-return valve with respect to the bottle.

One suggestion has been to cement the non-return valve in place using adhesives but the use of adhesives so close to the bottle's contents is not regarded as satisfactory. In the absence of alternative means of joining the non-return valve to the bottle, non-return valves have been manufactured of resilient material and designed so as to snap into position. The disadvantage of this approach however is that a persistant counterfeiter will eventually learn how to remove the non-return valve thus enabling him to refill the bottle.

According to a first aspect of the present invention there is provided a method of affixing a glass fitment or closure with respect to a glass bottle comprising the steps of providing a fusible material at an interface between said fitment or closure and said bottle, directing a high

energy density beam through said one of said fitment or closure or bottle substantially without causing any detectable change to the bulk thereof, and irradiating the fusible material with the high energy density beam to cause the fusible material to fuse and affix said fitment or closure with respect to said bottle.

According to a second aspect of the present invention there is provided a method of securing one body with respect to another comprising the steps of providing a fusible material at an interface of the two bodies, directing a high energy density beam through a first of the bodies substantially without causing any detectable change to the bulk thereof, and irradiating the fusible material with the high energy density beam so as to cause the fusible material to fuse and secure the two bodies with respect to each other.

Advantageously the step of providing a fusible material at an interface of the bodies concerned may comprise the printing of a layer of fusible material on a surface of one of said bodies. Alternatively the step of providing a fusible material at an interface of the body concerned may comprise the spraying of a layer of fusible material on to a surface of one of said bodies. Preferably said layer of fusible material may be cured prior to exposure to the high energy density beam. In another arrangement the step of providing a fusible material at an interface of the bodies concerned may comprise diffusing fusible material into a surface of one of said bodies. In yet a further arrangement the step of providing a fusible material at an interface of the bodies concerned may comprise interposing between said bodies a self supporting insert of fusible material.

Advantageously the fusible material may be selected from the list comprising a glass frit, a solder glass, a silicate or an enamel in a low melting wax.

Advantageously the fusible material may have a thermal expansion coefficient comparable with those of the two bodies so that upon cooling the fusible material forms a weld that is integral with each of said bodies.

Advantageously the high energy density beam may be adapted to have a power density at the fusible material of between $0.1W/mm^2$ and $500W/mm^2$.

Advantageously the high energy density beam may comprise a particle beam. Alternatively the high energy density beam may comprise a beam derived from a light source and in particular may comprise the beam of a laser. In this latter arrangement the laser may preferably be operated at a power within the range from 10-250W. Preferably the laser may comprise a YAG laser which is operated in a continuous wave mode and pulsed with a pulse duration of upto 10 seconds.

Advantageously the method may comprise the additional step of scanning the high energy density beam with respect to the fusible material. Preferably the step of scanning the high energy density beam may include providing at least one moveable mirror in the path thereof, the moveable mirror preferably comprising a galvanometer mirror.

Advantageously the method may comprise the additional step of focusing the high energy density beam on to the fusible material.

Advantageously the method may comprise the additional step of controlling the rate at which the two bodies and the fusible material are allowed to cool. Preferably the rate at which the two bodies and the fusible material are allowed to cool may be controlled by the supply of additional heat. Preferably this additional heat may be supplied by placing the two bodies and the fusible material within a furnace. Alternatively this additional heat may be supplied by irradiating the two bodies and the fusible material with a second high energy density beam.

In this latter arrangement the quantity of additional heat supplied to the two bodies and the fusible material may be controllably reduced by reducing the operating power of the second high energy density beam. Alternatively the quantity of additional heat supplied to the two bodies and the fusible material may be controllably reduced by de-focusing the second high energy density beam. In yet a further arrangement the quantity of additional heat supplied to the two bodies and the fusible material may be controllably reduced by actuating the second high energy density beam for progressively decreasing pulse durations.

Advantageously the second high energy density beam may comprise a particle beam. Alternatively the second high energy density beam may comprise a beam derived from a light source and in particular may comprise the beam of a laser. In this latter arrangement the laser beam should be at least partially absorbed in the material of the two bodies and so may preferably comprise the beam of a CO_2 laser.

Advantageously the first high energy density beam may be combined with the second high energy density beam such that the paths of the two beams are coincident, the two beams being combined upstream of any means to scan the first high energy density beam with respect to the fusible material.

Advantageously the method may comprise the additional step of focusing the second high energy density beam at the interface of the two bodies independently of the first high energy density beam.

According to a third aspect of the present invention there is provided an apparatus for securing one body with respect to another comprising means for creating a high energy density beam to which at least one of the bodies is transparent and which is absorbed by fusible material provided at an interface therebetween, means for directing a high energy density beam through said at least one of the

bodies so as to irradiate the fusible material and cause the fusible material to fuse and interconnect the two bodies, and means to control the rate at which the two bodies and the fusible material are allowed to cool.

Advantageously the high energy density beam may have a power density at the fusible material of between $0.1W/mm^2$ and $500W/mm^2$.

Advantageously the means for creating the high energy density beam may comprise a particle beam source. Alternatively the means for creating a high energy density beam may comprise a light source and in particular may comprise a laser. In this latter arrangement the laser may preferably have an operating power of within the range of 10-250W. Preferably the laser may comprise a YAG laser which is operated in a continuous wave mode and pulsed with a pulse duration of upto 10 seconds.

Advantageously means may be provided to scan the high energy density beam with respect to the fusible material. Preferably this scanning means may include at least one moveable mirror disposed in the path of the high energy density beam, the moveable mirror preferably comprising a galvanometer mirror.

Advantageously means may be provided to focus the high energy density beam on to the fusible material.

Advantageously the controlled cooling means may include means to heat the two bodies and the fused material. Advantageously this heating means may comprise a furnace or alternatively may comprise means for creating a second high energy density beam.

In this latter arrangement means may be provided to reduce the operating power of the second high energy density beam. Alternatively means may be provided to vary the extent to which the second high energy density beam is focused. In yet a further arrangement means may be provided to actuate the second high energy density beam to pulses of variable duration.

Advantageously the means for creating the second high energy density beam may comprise a particle beam source. Alternatively the means for creating the second high energy density beam may comprise a light source and in particular may comprise a laser. In this latter arrangement the laser beam should be at least partially absorbed in the material of the two bodies and so may preferably comprise the beam of a CO_2 laser.

Advantageously means may be provided to combine the first high energy density beam with the second high energy density beam such that downstream of the combining means the paths of the two beams are coincident, the combining means being placed upstream of any means to scan the first high energy density beam with respect to the fusible material.

Advantageously means may be provided to control the focus of the second high energy density beam at the interface of the two bodies independent of the first high energy density beam.

According to a fourth aspect of the present invention there is provided a glass bottle having a fitment or closure also of glass, the glass fitment or closure being fixed in position with respect to the bottle by means of fused glass.

Advantageously one or other of the fitment or closure and bottle is at least partially received within the other.

Advantageously the bottle, fitment or closure may incorporate a non-return valve.

Advantageously the fused glass may be integral with both the bottle and the fitment or closure. Alternatively, the fused glass may provide a keying action which prevents the separation of the fitment or closure from the bottle.

Advantageously the fused glass may be provided at intervals along the interface of the bottle and the fitment or closure.

Advantageously the fused glass may constitute a frangible zone.

According to a fifth aspect of the present invention there is provided an assembly comprising two bodies having a fusible material at an interface therebetween of which only a portion has been fused, the fused portion extending between the two bodies and securing each with respect to the other.

Advantageously one of the bodies is at least partially received within the other.

Advantageously the fused portion may be integral with both of the bodies. Alternatively, the fused portion may provide a keying action preventing relative movement of the two bodies in at least one direction.

Advantageously the fused portion may constitute a plurality of fused regions distributed over the interface between the two bodies.

Advantageously the fused portion may constitue a frangible zone.

Advantageously one or both of the bodies may be of glass and a fusible material selected from a list comprising a glass frit, a solder glass, a silicate or an enamel in a low melting wax.

A number of embodiments of the present invention will now be described by way of example with reference to the accompanying drawings in which:

Figure 1 is a cross-sectional view of two bodies to be secured with respect to one another having a layer of fusible material disposed therebetween;

Figure 2 is a cross-sectional view of the two bodies of Figure 1 showing a high energy density beam impinging upon the fusible material;

Figure 3 is a cross-sectional view of the two bodies of Figure 1 showing the fusible material bridging a gap between the two bodies;

Figure 4 is a cross-sectional view of the two bodies of Figure 1 showing the fusible material diffusing into the two bodies;

Figure 5 is a cross-sectional view of the two bodies of Figure 1 showing the weld formed by the fusible material broken away from the two bodies at the periphery of the diffused regions;

Figure 6 is a schematic cross-sectional view of two bodies secured with respect to each other by means of two "welds" similar to that shown in Figure 5;

Figure 7 is a schematic cross-sectional view of the neck of a glass bottle having a glass cap secured thereto;

Figure 8 is a cross-sectional view of the glass bottle of Figure 7 taken along the line VIII-VIII;

Figure 9 is a schematic cross-sectional view of a glass bottle having a glass insert secured thereto;

Figure 10 is a schematic view of an apparatus for securing one body with respect to another;

Figure 11 is a schematic view of a further embodiment of an apparatus for securing one body with respect to another; and

Figure 12 is a further embodiment of an apparatus for securing one body with respect to another.

Referring to Figures 1 to 4 there is shown in sequence the various stages in the formation of a weld between two bodies 10 and 12. In Figure 1 a first of the bodies 10 is shown as being provided on an area of its surface with a layer of fusible material 14. The second body 12 is spaced a short distance from the first body 10, typically 0.5mm, and in such a way that the fusible material 14 is interposed between the two. In Figure 2 a high energy density beam 16 is directed through the second body 12 to irradiate the fusible material 14 which fuses forming a molten globule 18. As the fusible material 14 continues to be irradiated by the high energy density beam 16 the molten globule 18 grows in size drawing in further fusbile material from either side. Eventually the molten globule 18 bridges the small gap between the two bodies 10 and 12 as shown in Figure 3. The high energy density beam

16 is then switched off and as the fusible material 14 cools it partially diffuses into the two bodies 10 and 12 forming diffused regions 20 and 22 as shown in Figure 4. The resulting weld 24 is of sufficient strength to secure together the two bodies 10 and 12.

It will be apparent to those skilled in the art that whilst the two bodies 10 and 12 have been described as being spaced a short distance apart this need not necessarily be the case. Indeed in some applications the two bodies 10 and 12 may be in contact with each other.

Since the fusible material 14 is to be irradiated through the second body 12 it is necessary that the second body 12 be of a material that does not substantially absorb the high energy density beam 16. In a preferred application of the present method the second body 12 is of glass. In this application the high energy density beam 16 preferably comprises a beam of laser radiation produced by a Yittrium Aluminium Garnet laser (YAG laser). A YAG laser produces laser radiation having a wavelength of 1.06μm which is highly transmitted by virtually all types of glass unlike the Carbon Dioxide laser (CO_2 laser) which produces laser radiation having a wavelength of 10.6μm which is highly absorbed by virtually all types of glasses.

The first body 10 need not be so restricted in its composition. However, as before, in a preferred application of the present method the first body 10 is of glass.

The fusible material 14 must clearly be capable of absorbing sufficient energy from the high energy density beam 16 in order to fuse and form the molten globule 18, and in the preferred application must be capable of absorbing laser radiation having a wavelength of 1.06μm. The fusible material 14 may however be capable of absorbing this energy either because of its composition or because of form, for example, in the case of the absorbtion of laser radiation, the fusible material 14 may

be in the form of a powder having a multiplicity of surfaces making it highly absorbant to laser radiation.

In addition to this the fusible material 14 should preferably also be capable of wetting the surfaces of the two bodies 10 and 12. Without this ability the molten globule 18 will form only a dry weld of insufficient strength to secure together the bodies concerned.

The fusible material 14 is preferably also one that has a low melting temperature. In this way it is possible to limit the energy density requirement of the high energy density beam 16.

Finally, the fusible material 14 is advantageously also capable of being easily applied to a first of the bodies 10. In a preferred embodiment the fusible material 14 is screen printed on to the desired surface in a layer 0.5mm thick while in another embodiment the fusible material 14 is applied to the first body 10 by means of a spraying operation. In each of these embodiments the fusible material 14 is preferably heat cured (as distinct from being fired) prior to being irradiated by the high energy density beam 16. In another embodiment the fusible material 14 comprises a diffused layer on a surface of the first body 10 while in yet another embodiment the fusible material 14 comprises a self supporting insert disposed between the two bodies 12 and 14.

Whilst in all of the above embodiments the fusible material 14 has been described as being applied to the first of the bodies 10, it will be apparent to those skilled in the art that the fusible material 14 may equally be applied to the second of the bodies 12.

Having identified the foregoing constraints and preferred characteristics the fusible material 14 prefably comprises a solder glass such as X88 or X49BK. Advantageously the solder glass may be in the form of a frit comprising ground or powdered glass in a binder. In an alternative embodiment the fusible material 14 comprises

a blue enamel dispersed in a low melting wax. In yet another embodiment the fusible material 14 comprises a silicate.

As previously stated, the character of the high energy density beam 16 is at least partially dependant upon the composition of the second body 12. However within the constraints imposed by the composition of the second body 12 it will be apparent to those skilled in the art that the high energy density beam 16 may comprise a particle beam.

Whilst the composition of the second body 12 at least partially determines the character of the high energy density beam 16 it is the absorbtion characteristics and melting temperature of the fusible material 14 that determines its required energy density. By appropriate selection of the fusible material 14 the YAG laser of the preferred application may be operated in a contiuous wave (CW) mode as opposed to a pulsed mode.

Furthermore, again by appropriate selection of the fusible material 14, the laser radiation produced by the YAG laser may require little or no focusing in order to achieve the necessary energy density. Thus in the preferred application and using a typical glass a 36W CW YAG laser is used to generate a beam having a diameter of approximately 3mm by passing through a 50mm focal length lens placed some 78mm from the fusible material 14. The resulting energy density of $5W/mm^2$ has been found sufficient to raise the temperature of the solder glass to a point at which it may fuse, wet the surfaces of the two bodies 10 and 12 and form the desired weld all within a pulse duration of about 1 second.

Clearly by using as the fusible material 14 a frit that has already been flowed this pulse length could be decreased still further since the high energy density beam 16 would only be required to raise the temperature of the fusible material until it could wet the surfaces of the two bodies 10 and 12.

One of the problems experienced in the welding together of glass bodies using the above method is that having formed the weld shown in Figure 4 often one or other, but occasionally both, of the bodies subsequently undergo a catastrophic failure. It has been found that, as shown in Figure 5, the weld 24 cracks at the periphery of the diffused regions 20 and 22 forming a spigot having an axial length slightly in excess of the distance between the two bodies 10 and 12.

This cracking occurs as a result of differences between the thermal expansion coefficients of the fusible material 14 and the glass of the two bodies 10 and 12. Thus once the high energy density beam 16 has been switched off and both the weld 24 and the two bodies 10 and 12 begin to cool they contract at different rates setting up internal stresses that result in the cracking described. Different glasses exhibit a wide range of thermal expansion coefficients from 40×10^{-7} m/m/°C to 100×10^{-7} m/m/°C. By selecting a fusible material 14 having a thermal expansion coefficient similar to those of the bodies to be welded the problem of cracking can be minimised. To this end the solder glasses X88 and X49BK are particularly useful having thermal expansion coefficients of 88×10^{-7} m/m/°C and 49×10^{-7} m/m/°C respectively.

The problem of cracking can be overcome completely by controlling the rate at which the weld 24 and the two bodies 10 and 12 cool once the high energy density beam 16 has been removed. It has been found that so long as the cooling rate is controlled through a critical annealing range it does not matter how rapidly the weld 24 and the two bodies 10 and 12 are cooled outside this range.

To this end the welding of the two bodies 10 and 12 may take place within a furnace operating at a temperature above the upper limit of the annealing range. As before a high energy density beam 16 is directed through one of the

bodies 12 to irradiate the fusible material 14. However once the weld 24 has been formed and the high energy density beam 16 is switched off the weld 24 and the two bodies 10 and 12 may only cool to the temperature of the furnace. Thereafter the temperature of the furnace may be gradually reduced until it is below the lower limit of the annealing range. At this stage the two bodies 10 and 12 may be removed from the furnace and allowed to cool still further by some other mechanism.

In another arrangement the weld 24 and the two bodies 10 and 12 may be impinged by a second high energy density beam in addition to that which causes the fusing of the fusible material 14. The second high energy density beam, like the furnace of the previous arrangement, would serve to supply heat to the weld 24 and the two bodies 10 and 12 so as to control the rate at which they would otherwise cool through the annealing range. To this end the second high energy density beam must be one that is at least partially absorbed in glass. Whilst it will be apparent to those skilled in the art that the second high energy density beam may comprise a particle beam in a preferred embodiment the second high energy density beam comprises a beam of laser radiation produced by a CO_2 laser operating at a wavelength of 10.6μm. By defocusing the beam so as to have a diameter of approximately 10mm heat may be supplied to the whole of the area surrounding the weld 24.

Once the first high energy density beam has been switched off the quanitity of heat supplied to the weld 24 and the surrounding area of the two bodies 10 and 12 may be reduced by either reducing the power of the CO_2 laser or defocusing the beam still further. Alternatively the CO_2 laser may be actuated for progressively decreasing pulse durations. When the temperature of the two bodies 10 and 12 is below the lower limit of the annealing range the second high energy density beam may also be switched off.

One advantage of using secondary heat sources such as the furnace and CO_2 laser described, is that less heat need be generated by the first high energy density beam 16. This in turn can be translated into a shorter pulse length, a reduction in the power requirement of the YAG laser or a negation of the requirement to focus the beam.

Alternatively the cracking of the weld 24 may be used to advantage. As shown in Figure 5 the cracking results in the formation of a spigot whose opposite ends 20 and 22 are received within one of a respective pair of recesses 26 or 28 formed in the opposing surfaces of the two bodies 10 and 12. The spigot consequently has a keying or wedge-like action which, depending on the configuration of the two bodies 10 and 12 and on the number and configuration of other "welds" 24, may be sufficient to secure together the bodies concerned.

This method of securing two bodies together is particularly advantageous when one of the bodies 10 is received within the other 12 as shown in Figure 6. In this arrangement the provision of one or more "welds" 24 between pairs of diametrically opposed surfaces is sufficient to secure the two bodies together.

Thus for example a glass cap 30 may be "welded" to the neck 32 of a glass bottle 34. As shown in Figure 7 the cap 30 may comprise a generally circular disc 36 of sufficient size to overlie a mouth 38 of the bottle 34 having a central bore 41 and a depending skirt 40 capable of receiving the neck 32. The bottle 34 on the other hand may be provided on an external surface of the neck 32 with a screen printed layer 44 of the solder glass X88.

Once the bottle 34 has been filled with its contents 46 the glass cap 30 may be placed over the mouth 38 taking care not to scratch the screen printed layer 44 with the depending skirt 40. This is made easier by the partial

curing of the screen printed layer prior to filling of the bottle 34. A beam of a partially focused YAG laser is then directed through the depending skirt 40 of the cap 30 to irradiate a small area of the screen printed layer 44. The laser radiation has substantially no effect on the material of the cap 30 but is highly absorbed by the solder glass. The solder glass fuses forming a molten globule that first wets the opposed surfaces of the neck 32 and the depending skirt 40 before then bridging the gap between the two and forming a weld 48. The laser is switched off and the cap 30, the bottle 34 and the weld 48 all begin to cool during which time the solder glass diffuses into both the neck 32 and the depending skirt 40. As the cooling process continues stresses are set up in the material of both the cap 30 and the bottle 34 which eventually results in the fracturing of the weld 48 at the periphery of the regions in both the neck 32 and the depending skirt 40 in which the solder glass has diffused.

The cap and bottle 30 and 34 are rotated with respect to the laser and the process repeated irradiating another small area of the screen printed layer 44 and forming a second weld 48 which again is allowed to fracture once the laser has been switched off.

By repeating the process a number of times it is possible to arrive at the situation shown in Figure 8 in which the cap 30 is secured to the bottle 34 by means of a multiplicity of spigots each having a keying action.

It will be apparent to those skilled in the art that the cap 30 need not be secured to the bottle 34 by means of a plurality of "spot welds" but may be secured by means of an elongate weld should the laser beam be scanned at an appropriate rate around the screen printed layer 44. One advantage of using spot welds however is that they provide

a frangible zone that will break if tampered with and so provide evidence of mishandling. In contrast an elongate weld would result in a cap that could rotate with respect to the bottle. Such a cap may be used to mechanically stress the neck of the bottle and so be eased off.

In another application a glass plug 50 may be "welded" in position within the neck 52 of a second glass bottle 54. As shown in Figure 9 the bottle 54 is provided with an annular flange 56 that projects from an inner surface of the neck 52. The glass plug 50 on the other hand is provided with a central bore 58 and is so sized as to be capable of being received within the neck 52 and engaging the annular flange 56. An external surface of the plug 50 is provided with a layer 62 of the solder glass X49BK.

Once the bottle 54 has been filled with its contents 63 the glass plug 50 is inserted into the neck 52 so that it abuts the annular flange 56. As in the previous example, care is taken not to scratch the layer 62 upon insertion of the plug 50 although this layer 62 may be made more robust by being partially cured prior to the filling of the bottle 54. A beam from a partially focsed YAG laser is then directed through the neck 52 to irradiate a small spot on the layer of solder glass 62. As before the laser radiation has substantially no affect on the material through which it is directed but is highly absorbed by the solder glass. The solder glass fuses and forms a molten globule before then wetting the opposed surfaces this time of the plug 50 and the neck 52 and bridging the gap between the two to form a weld 64. The laser is switched off and the plug 50, the bottle 54 and the weld 64 are allowed to cool during which time the solder glass diffuses into both the plug 50 and neck 52. Eventually the weld 64 cracks leaving a spigot of solder glass to retain the plug 50 within the neck 52.

As in the previous example the process may be repeated to provide a plurality of "spot welds" between the plug 50 and the bottle 54. As before this provides a way in which a plug 50 may be fixed in the neck of a filled bottle.

In the applications described the use of laser radiation to "weld" together two glass components has replaced the use of adhesives with all their associated problems. Furthermore, by taking advantage of the cracking of the welds it is possible to dispense with the need to control the cooling of the weld after the removal of the high energy density beam. This not only speeds up the "welding" process but also negates the use of additional heat which may be deleterious to the contents of the bottle.

In summary therefore an apparatus for securing two bodies together may be seen in Figure 10 to comprise means 66 for creating a high energy density beam 68 to which at least one of the bodies 70 or 72 is transparent and which is absorbed by a fusible material 74 interposed between the two, and means 76 for directing the high energy density beam 68 through said at least one of the bodies 70 to irradiate the fusible material 74 and cause the fusible material to fuse and join the two bodies 70 and 72.

As has been previously stated, the means 66 for creating the high energy density beam 68 may comprise a particle beam source, however in the embodiment shown the means 66 for creating the high energy density beam 68 comprises a laser. If the body 70 through which the beam 68 is directed is of glass the laser 66 preferably comprises a YAG laser although clearly if this body 70 is not of glass an alternative laser 66 may be more appropriate. Assuming the two bodies to be secured together 70 and 72 are of glass the laser 66 preferably has a power within the range from 10 to 250 Watts and operates in CW mode for a pulse duration of up to 10 seconds.

The means 76 for directing the high energy density beam 68 through said at least one of the bodies 70 may comprise one or more mirrors 78 and in particular may comprise at least one moveable mirror 80. The provision of a moveable mirror 80 within the path of the high energy density beam 68 enables the apparatus to adjust for any misalignment between the bodies to be secured and the means 66 for creating the high energy density beam 68 whilst at the same time enabling the creation of an elongate weld should this be desired. In a preferred arrangement the at least one moveable mirror 80 may comprise a galvanometer mirror. Whilst it will be recognised that any suitable means may be provided to control the movement of the moveable mirror 80, such as the use of a servo motor or a manual joystick, the use of a galvanometer mirror combines a speed of response with an ease of control that represents a significant advantage over alternative control means.

As shown in Figure 10 the high energy density beam 68 may pass through a focusing means 82 before impinging upon the fusible material 74 in which case the focusing means 82 may comprise at least one lens element 84. As has been previously stated, the degree to which the high energy density beam 68 is focused provides a means of controlling its power density. The power density required to cause a typical fusible material 74 to fuse may be in the range from $0.1W/mm^2$ to $500W/mm^2$ and so a laser 66 having a power within the preferred range may require little or no focusing.

In order to prevent the resulting weld from cracking once the means 66 for creating the high energy density beam 68 has been switched off the bodies to be secured together 70 and 72 may be housed within a furnace 86 as shown in Figure 11. The furnace 86 may be of sufficient size to enclose not only the two bodies 70 and 72 but also the means 66 for creating the high energy density beam 68 and the means 76 for directing the high energy density beam 68

through said at least one of the bodies 70. In a preferred arrangement however the means 66 for creating the high energy density beam 68 and the means 76 for directing the high energy density beam 68 are disposed externally of the furnace 86 and the furnace 86 provided with either an opening or a transparent window 88 to allow the high energy density beam 68 to irradiate the fusible material 74 interposed between the two bodies 70 and 72. In either event the furnace 86 is preferably provided with means 90 to monitor and control the temperature of the two bodies 70 and 72 as they pass through the annealing range.

In an alternative embodiment shown in Figure 12 there is provided a second high energy density beam source 92. As previously stated, this second high energy density beam source 92 preferably comprises a CO_2 laser whose resulting radiation 94 is directed so as to irradiate the area of the two bodies 70 and 72 immediately surrounding the weld produced as a result of the first high energy density beam 68. In a preferred arrangement the two high energy density beams 68 and 94 are superimposed using a beam combiner 96 upstream of the means 76 for directing the first high energy density beam 68. In this way the radiation 94 emitted by the CO_2 laser 92 may be constrained to follow the path of the first high energy density beam 68 irrespective of any deflections caused by the mirror 78 or 80.

In a further preferred embodiment the radiation 94 emitted by the CO_2 laser 92 passes through an independent focusing means 98 before impinging upon the beam combiner 96. In this way the energy density of the second high energy density beam 94 may be controlled independently of the first 68 in order to provide a change in its heating effect.

As with the furnace 86 of the previous embodiment, means 100 are provided to monitor and control the temperature of the two bodies 70 and 72 as they pass through the annealing range.

CLAIMS

1. A method of affixing a glass fitment or closure with respect to a glass bottle comprising the steps of providing a fusible material at an interface between said fitment or closure and said bottle, directing a high energy density beam through one of said fitment or closure or bottle substantially without causing any detectable change to the bulk thereof, and irradiating the fusible material with the high energy density beam so as to cause the fusible material to fuse and affix said fitment or closure with respect to said bottle.

2. A method of securing one body with respect to another comprising the steps of providing a fusible material at an interface of the two bodies, directing a high energy density beam through a first of the bodies substantially without causing any detectable change to the bulk thereof, and irradiating the fusible material with the high energy density beam so as to cause the fusible material to fuse and secure the two bodies with respect to each other.

3. A method in accordance with Claim 1 or Claim 2, wherein the step of providing a fusible material at an interface of the bodies concerned comprises the printing of a layer of fusible material on a surface of one of said bodies.

4. A method in accordance with Claim 1 or Claim 2, wherein the step of providing a fusible material at an interface of the bodies concerned comprises the spraying of a layer of fusible material onto a surface of one of said bodies.

5. A method in accordance with Claim 3 or Claim 4, wherein said layer of fusible material is cured prior to exposure to the high energy density beam.

6. A method in accordance with Claim 1 or Claim 2, wherein the step of providing a fusible material at an interface of the bodies concerned comprises diffusing fusible material into a surface of one of said bodies.

7. A method in accordance with Claim 1 or Claim 2, wherein the step of providing a fusible material at an interface of the bodies concerned comprises interposing between said bodies a self-supporting insert of fusible material.

8. A method in accordance with any preceding claim, wherein the fusible material is selected from the list comprising a glass frit, a solder glass, a silicate or an enamel in a low melting wax.

9. A method in accordance with any preceding claim, wherein the fusible material has a thermal expansion coefficient comparable with those of the two bodies concerned such that upon cooling the fusible material forms a weld that is integral with each of said bodies.

10. A method in accordance with any preceding claim, wherein the high energy density beam is adapted so as to have a power density at the fusible material of between 0.1W/mm^2 and 500W/mm^2

11. A method in accordance with any preceding claim, wherein the high energy density beam comprises a beam derived from a light source.

12. A method in accordance with any of claims 1 to 10, wherein the high energy density beam comprises a particle beam.

13. A method in accordance with any of Claims 1 to 11, wherein the high energy density beam comprises the beam of a laser.

14. A method in accordance with Claim 13, wherein the laser is operated at a power within the range from 10 to 250 Watts.

15. A method in accordance with Claim 13 or Claim 14, wherein the laser comprises a YAG laser.

16. A method in accordance with Claim 15, wherein the YAG laser is operated in a continuous wave mode and pulsed with a pulse duration of up to 10 seconds.

17. A method in accordance with any preceding claim and comprising the additional step of scanning the high energy density beam with respect to the fusible material.

18. A method in accordance with Claim 17, wherein the step of scanning of the high energy density beam includes providing at least one movable mirror in the path thereof.

19. A method in accordance with Claim 18, wherein said at least one movable mirror comprises a galvanometer mirror.

20. A method in accordance with any preceding claim and comprising the additional step of focusing the high energy density beam onto the fusible material.

21. A method in accordance with any preceding claim and comprising the additional step of controlling the rate at which the two bodies and the fusible material are allowed to cool.

22. A method in accordance with Claim 21, wherein the rate at which the two bodies and the fusible material are allowed to cool is controlled by the supply of additional heat.

23. A method in accordance with Claim 22, wherein said additional heat is supplied by placing the two bodies and the fusible material within a furnace.

24. A method in accordance with Claim 22, wherein said additional heat is supplied by irradiating the two bodies and the fusible material with a second high energy density beam.

25. A method in accordance with Claim 24, wherein the quantity of the additional heat supplied to the two bodies and the fusible material is controllably reduced by reducing the operating power of the second high energy density beam.

26. A method in accordance with Claim 24 or Claim 25, wherein the quantity of additional heat supplied to the two bodies and the fusible material is controllably reduced by defocusing the second high energy density beam.

27. A method in accordance with any of Claims 24 to 26, wherein the quantity of additional heat supplied to the two bodies and the fusible material is controllably reduced by actuating the second high energy density beam for progressively decreasing pulse durations.

28. A method in accordance with any of claims 24 to 27, wherein said second high energy density beam comprises a beam derived from a light source.

29. A method in accordance with any of Claims 24 to 27, wherein said second high energy density beam comprises a particle beam.

30. A method in accordance with any of Claims 24 to 28, wherein said second high energy density beam comprises the beam of a laser.

31. A method in accordance with Claim 30, wherein said laser comprises a CO_2 laser.

32. A method in accordance with any of Claims 24 to 31, wherein the first high energy density beam is combined with said second high energy density beam such that the paths of the two beams are coincident, the two beams being combined upstream of any means to scan the first high energy density beam with respect to the fusible material.

33. A method in accordance with any of Claims 24 to 32 and including the additional step of focusing the second high energy density beam at the interface of the two bodies independently of said first high energy density beam.

34. An apparatus for securing one body with respect to another comprising means for creating a high energy density beam to which at least one of the bodies is transparent and which is absorbed by fusible material provided at an interface therebetween, means for directing the high energy density beam through said at least one of the bodies so as to irradiate the fusible material and cause the fusible material to fuse and interconnect the two bodies, and means to control the rate at which the two bodies and the fused material are allowed to cool.

35. An apparatus in accordance with Claim 34, wherein said controlled cooling means includes means to heat the two bodies and the fused material.

36. An apparatus in accordance with Claim 35, wherein said heating means comprises a furnace.

37. An apparatus in accordance with Claim 35, wherein said heating means comprises means for creating a second high energy density beam.

38. An apparatus in accordance with Claim 37, wherein means are provided to reduce the operating power of the second high energy density beam.

39. An apparatus in accordance with Claim 37 or claim 38, wherein means are provided to vary the extent to which the second high energy density beam is focused.

40. An apparatus in accordance with any of Claims 37 to 39, wherein means are provided to actuate the second high energy density beam for pulses of variable duration.

41. An apparatus in accordance with any of claims 37 to 40, wherein said means for creating a second high energy beam comprises a light source.

42. An apparatus in accordance with any of Claims 37 to 40, wherein said means for creating a second high energy density beam comprises a particle beam source.

43. An apparatus in accordance with any of Claims 37 to 41, wherein said means for creating a second high energy density beam comprises a laser.

44. An apparatus in accordance with Claim 43, wherein said laser comprises a CO_2 laser.

45. An apparatus in accordance with any of Claims 37 to 44, wherein means are provided to combine the first high energy density beam with said second high energy density

beam such that downstream of said combining means the paths of the two beams are coincident, said combining means being placed upstream of any means to scan the first high energy density beam with respect to the fusible material.

46. An apparatus in accordance with any of Claims 37 to 45, wherein means are provided to control the focus of the second high energy density beam at the interface of the two bodies independently of the first high energy density beam.

47. A glass bottle having a fitment or closure also of glass, the glass fitment or closure being fixed in position with respect to the bottle by means of fused glass.

48. A glass bottle in accordance with claim 47, wherein one or other of said fitment or closure and bottle is at least partially received within the other.

49. A glass bottle in accordance with claim 47 or claim 48, wherein said bottle, fitment or closure incorporates a non-return valve.

50. A glass bottle in accordance with any of claims 47 to 49, wherein said fused glass is integral with both said bottle and said fitment or closure.

51. A glass bottle in accordance with any of claims 47 to 49, wherein said fused glass provides a keying action which prevents the separation of said fitment or closure from said bottle.

52. A glass bottle in accordance with any of claims 47 to 51, wherein said fused glass is provided at intervals along the interface between said bottle and said fitment or closure.

53. A glass bottle in accordance with any of claims 47 to 52, wherein said fused glass constitutes a frangible zone.

54. An assembly comprising two bodies having a fusible material at an interface therebetween of which only a portion has been fused, the fused portion extending between the two bodies and securing each with respect to the other.

55. An assembly in accordance with claim 54, wherein one of said bodies is at least partially received within the other.

56. An assembly in accordance with claim 54 or claim 55, wherein said fused portion is integral with both the said bodies.

57. An assembly in accordance with claim 54 or claim 55, wherein said fused portion provides a keying action preventing relevant movement between said two bodies in at least one direction.

58. An assembly in accordance with any of claims 54 to 57, wherein said fused portion constitutes a plurality of fused regions distributed over the interface between said two bodies.

59. An assembly in accordance with any of claims 54 to 58, wherein said fused portion constitutes a frangible zone.

60. An assembly in accordance with claims 54 to 59, wherein one or both of the said bodies are of glass.

61. An assembly in accordance with any of claim 54 to 60, wherein said fusible material is selected from the list comprising a glass frit, a solder glass, a silicate or an enamel in a low melting wax.

FIG. 1.

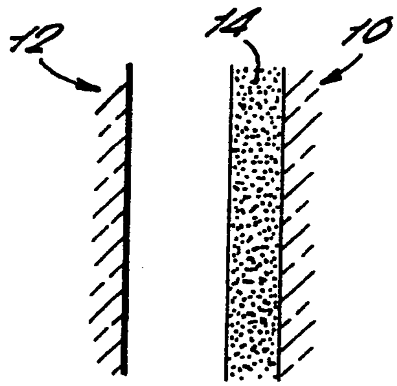


FIG. 2.

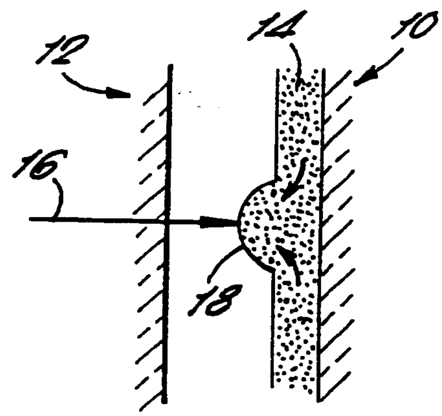


FIG. 3.

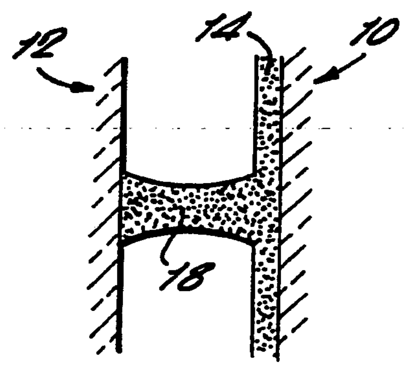


FIG. 4.

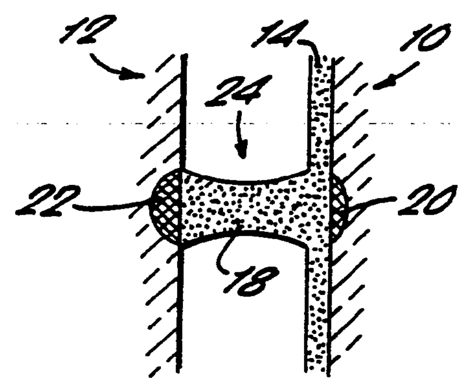


FIG. 5.

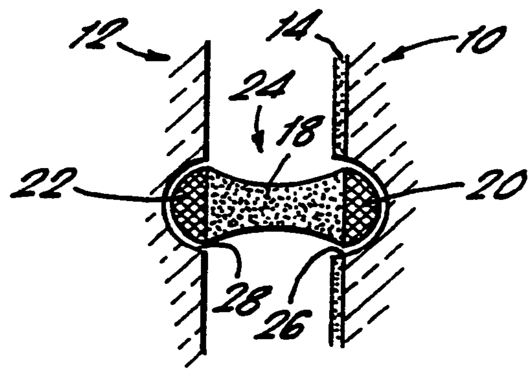


FIG. 6.

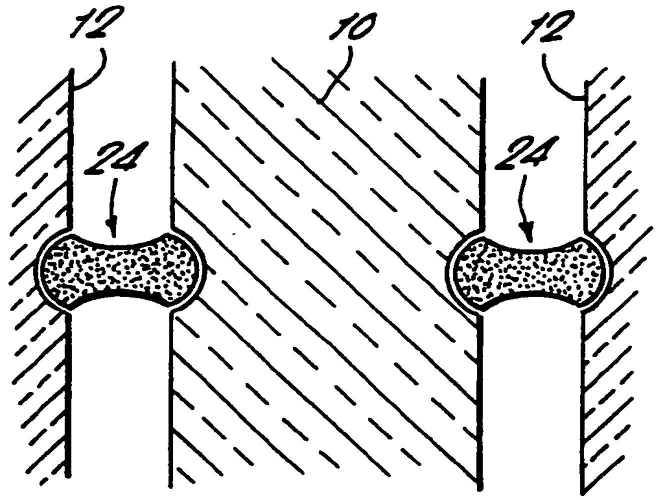


FIG. 7.

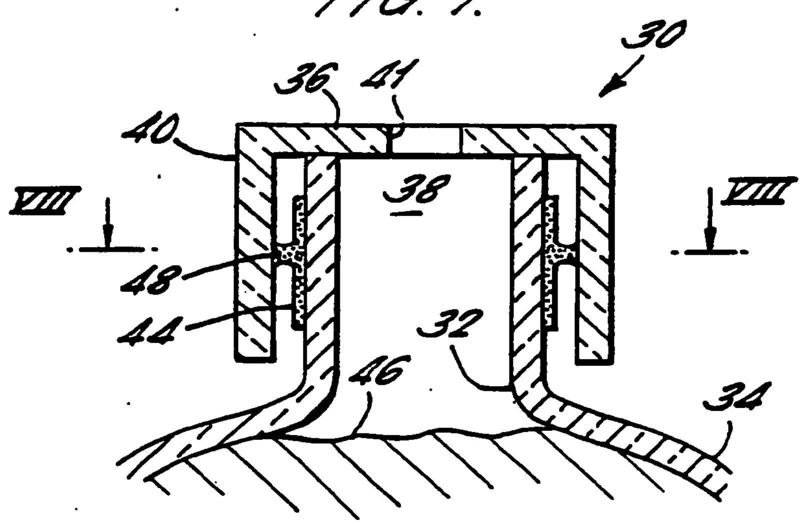


FIG. 8.

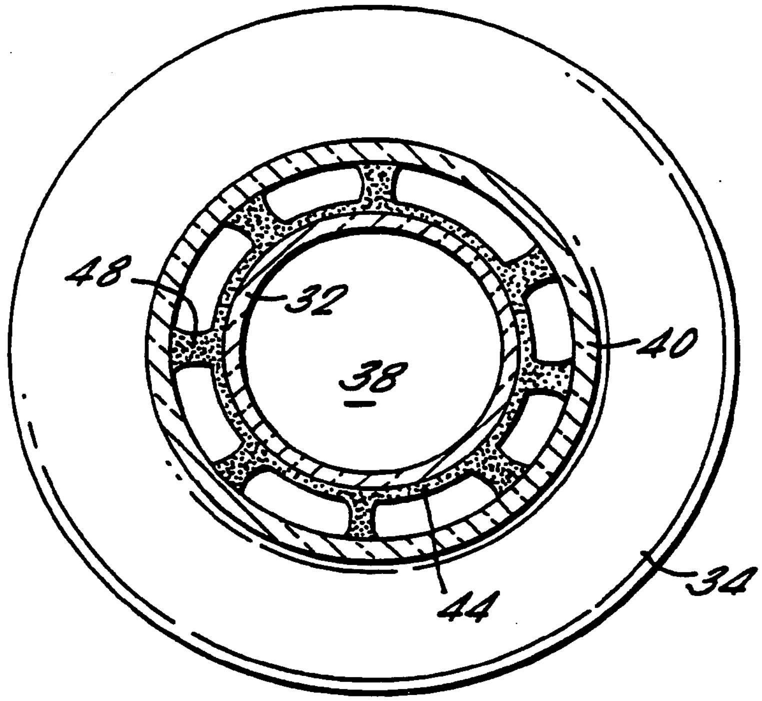
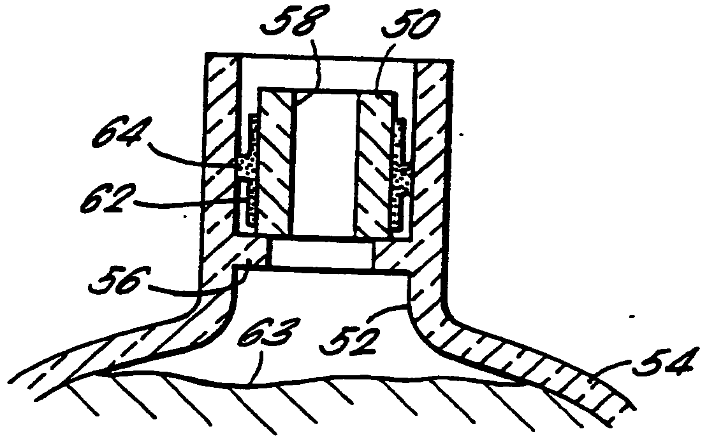


FIG. 9.



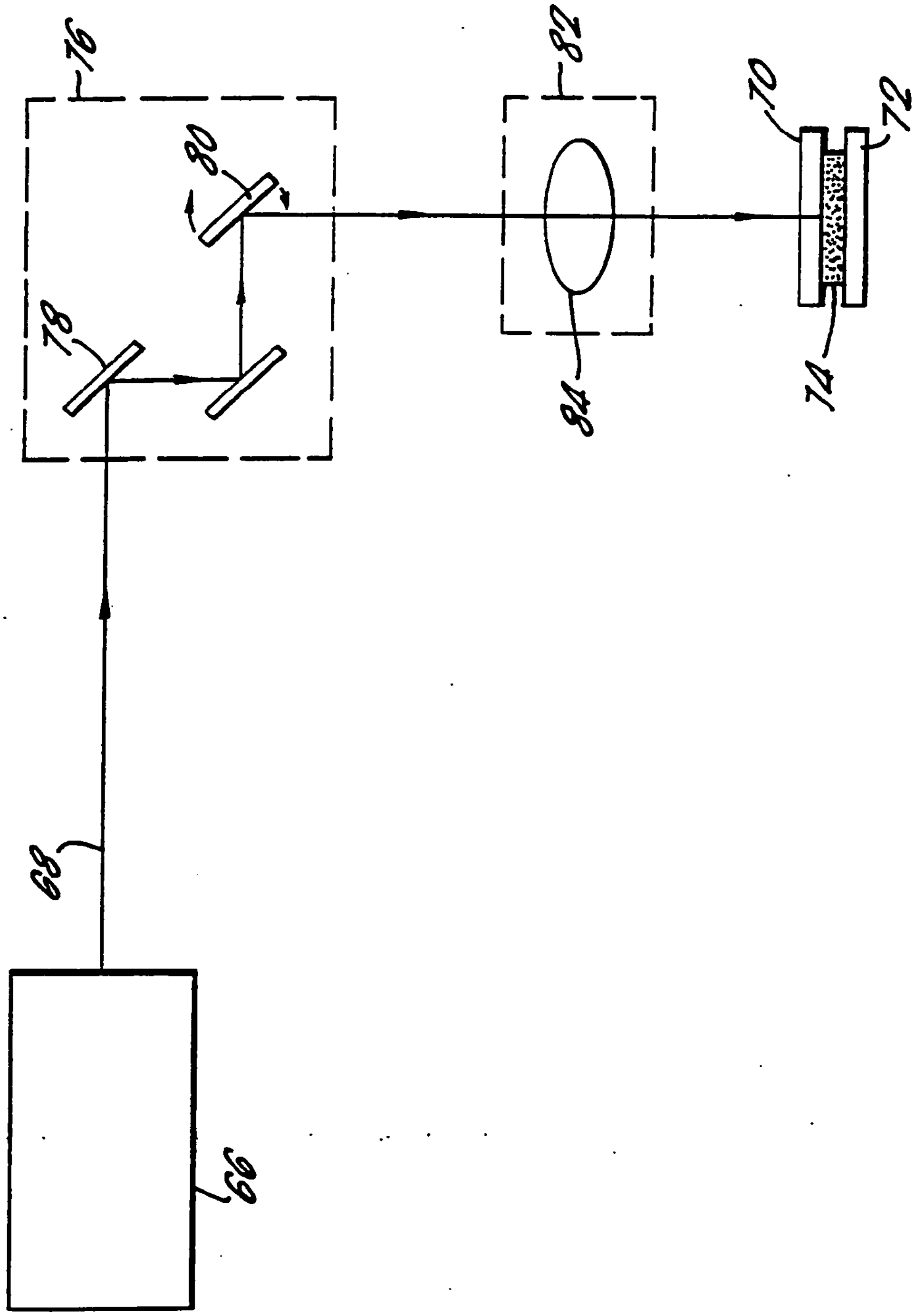


FIG. 10.

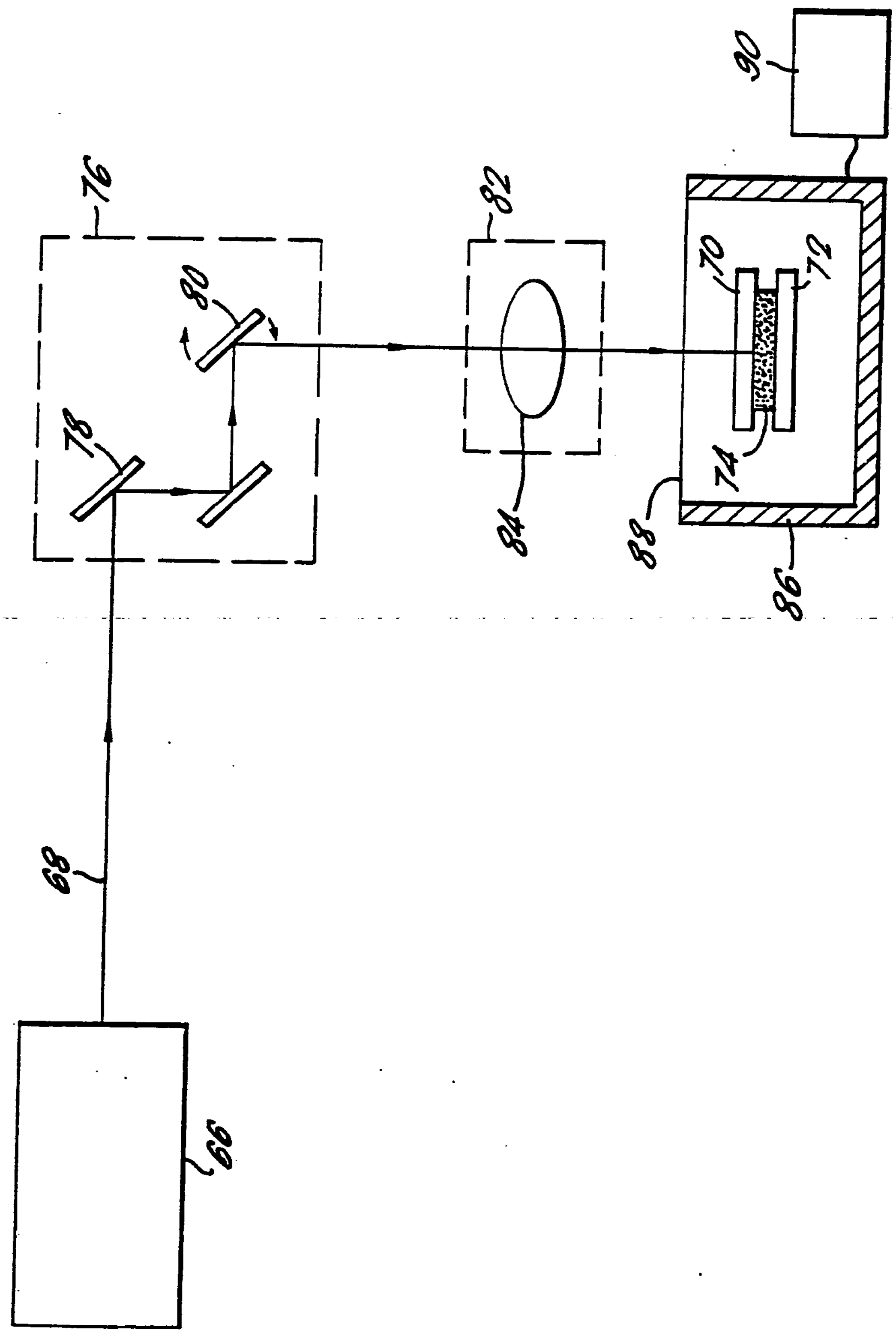


FIG. 11.

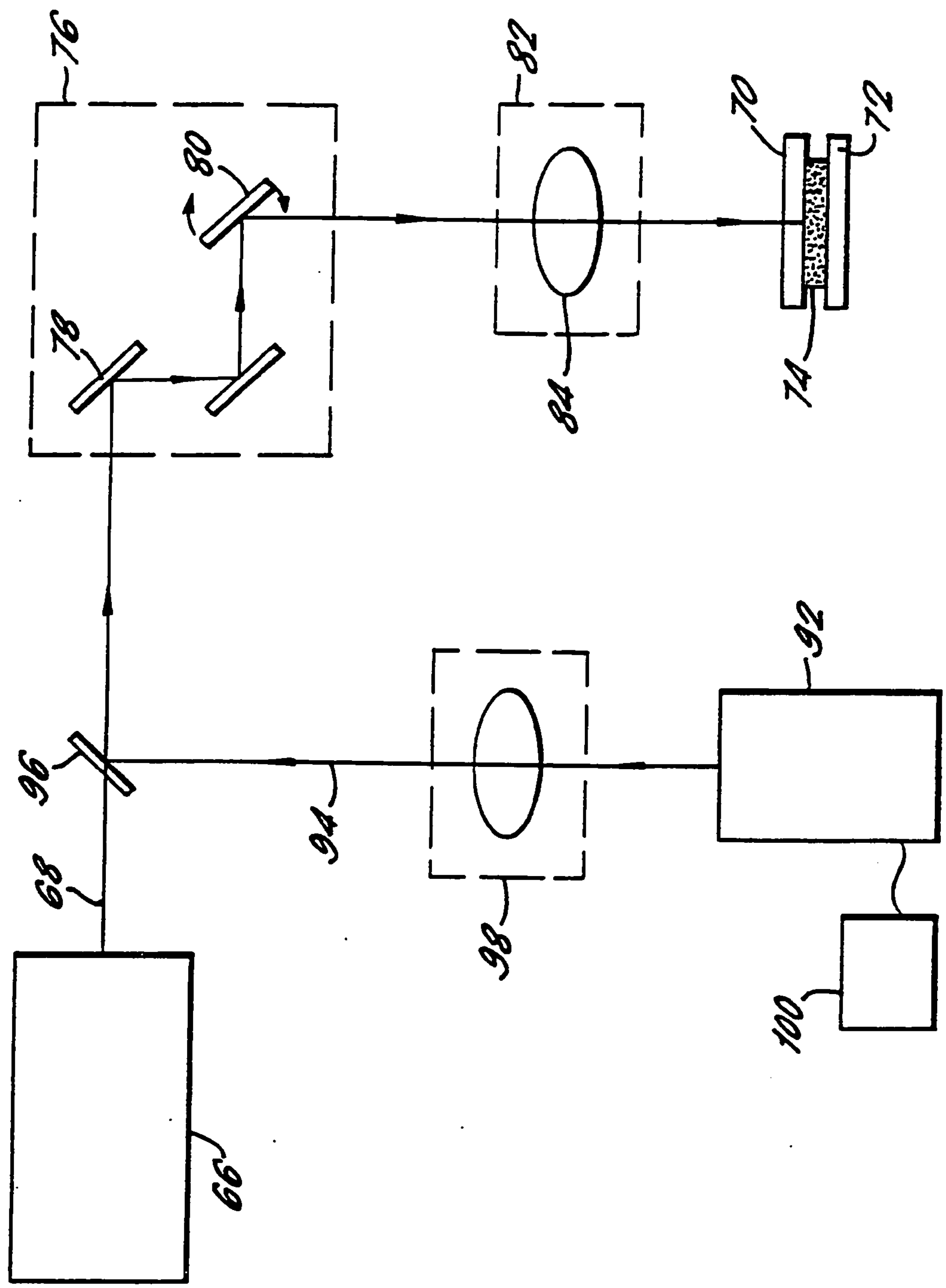


FIG. 12.

INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 92/02301

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 C03C27/06; B65D55/02

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl. 5	C03C ; B65D ; B23K

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category °	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No.[13]
X	CHEMICAL ABSTRACTS, vol. 109, no. 22, 28 November 1988, Columbus, Ohio, US; abstract no. 195897x, page 362 ; see abstract & JP,A,63 129 045 (TOSHIBA CORP.) 1 June 1988	2,7,8, 10,11, 13-15
A	WO,A,8 905 209 (OTIC FISCHER & PORTER S.A.) 15 June 1989 see claims	1-5,10, 11, 13-15,34

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° Special categories of cited documents : [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

1

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
17 FEBRUARY 1993	22. 03. 93
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	VAN BOMMEL L.

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)		
Category °	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
A	DATABASE WPIL Section Ch, Week 8330, 1983 Derwent Publications Ltd., London, GB; Class L, AN 83-720701 & JP,A,58 104 047 (NIPPON ELECTRIC K.K.) 21 June 1983 see abstract ---	1-5,10, 11,13,34
A	US,A,3 120 433 (VAN ZEE) 4 February 1964 ---	
A	GB,A,2 019 387 (THE PLESSEY COMPANY, LTD.) 31 October 1979 -----	

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO.

GB 9202301
SA 67528

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information. 17/02/93

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
WO-A-8905209	15-06-89	FR-A-	2624041	09-06-89
		AU-A-	2794889	05-07-89
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US-A-3120433		None		
GB-A-2019387	31-10-79	US-A-	4265689	05-05-81

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82